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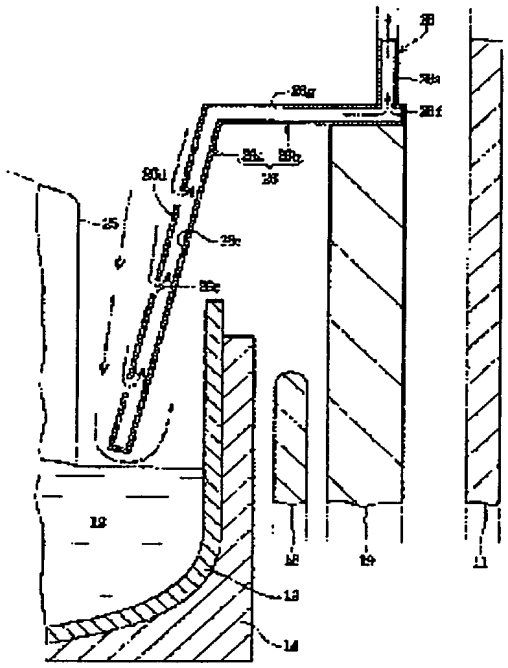
(54) APPARATUS FOR PULLING SILICON SINGLE CRYSTAL

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an apparatus for pulling a silicon single crystal, capable of preventing contamination of the silicon single crystal bar by an impurities mixed with an inert gas, and capable of providing the silicon single crystal bar with high purity.
SOLUTION: A silicon molten liquid 12 is stored in a quartz crucible 13 installed in a chamber 11, and the silicon molten liquid is heated by a heater 18 surrounding the outer periphery of the quartz crucible 13. A heat-blocking member 26 surrounding the outer periphery of the silicon single crystal bar 25 pulled from the silicon molten liquid 12 and having lower end positioned at the upper part of the surface of the silicon molten liquid 12 at a distance blocks radiant heat from the heater 18, and a gas-supplying means allows an inert gas to flowing down between the silicon single crystal bar 25 and the heat-blocking member 26, to pass on the surface of the silicon molten liquid 12 and to be discharged to the exterior of the chamber 11. An impure gas- discharging means 28 sucks the inert gas flowing down along the surface of the heat blocking member 26 in the inert gas flowing down between the silicon single crystal bar 25 and the heat-blocking member 26 and discharges the sucked gas into the exterior of the chamber 11.



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CLAIMS

[Claim(s)]
[Claim 1] The quartz crucible with which it was prepared in the chamber (11) and silicon melt (12) was stored (13), The heater which surrounds the peripheral face of said quartz crucible (13), and heats said silicon melt (12) (18), The thermal shield member which surrounds the peripheral face of the silicon single crystal rod (25) which can be pulled up from said silicon melt (12), and a lower limit opens spacing from said silicon melt (12) front face, is located up, and interrupts the radiant heat from said heater (18) (26 56), In the pull-up equipment of the silicon single crystal equipped with a gas feeding-and-discarding means (27) to make flow down inert gas between said silicon single crystal rod (25) and said thermal shield member (26 56), and to make pass through said silicon melt (12) front face, and to discharge out of said chamber (11) Said inert gas which flows down along the front face of said thermal shield member (26 56) among the inert gas which flows down between said silicon single crystal rod (25) and said thermal shield member (26 56) is attracted. Pull-up equipment of the silicon single crystal characterized by having an impure gas discharge means (28 58) to discharge out of said chamber (11).
[Claim 2] The cavernous section by which the impure gas discharge means (28) was formed in the thermal shield member (26) (26c), Two or more impure gas suction holes opened for free passage and formed in the inner circle wall (26d) of said thermal shield member (26) at said cavernous section (26c) (26e), The impure gas discharge hole opened for free passage and formed in the upper part of said thermal shield member (26) at said cavernous section (26c) (26f), Pull-up equipment of the silicon single crystal according to claim 1 which has the aspirator which was formed out of the chamber (11) and connected to said impure gas discharge hole (26f) through the impure gas discharge pipe (28a).
[Claim 3] Pull-up equipment of the silicon single crystal according to claim 1 which has the aspirator by which the impure gas discharge means (58) was established the impure gas suction pipe (58a) which is arranged by the inner skin of a thermal shield member (56), and has two or more impure gas suction holes (58b), and out of the chamber (11), and was connected to said impure gas suction pipe (58a).

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the equipment which pulls up and raises a silicon single crystal rod.
[0002]
[Description of the Prior Art] Conventionally, as this kind of equipment, as shown in drawing 7 , the quartz crucible 3 with which silicon melt 2 was stored is held in a chamber 1, the thermal shield member 6 is inserted so that the silicon single crystal rod 5 may be surrounded between the peripheral face of the silicon single crystal rod 5, and the inner skin of the quartz crucible 3, and that by which the upper limit of the thermal shield member 6 was further jutted out over the abbreviation horizontal direction by the method of outside is known. With this equipment, the thermal shield member 6 is formed in tubed [to which a diameter becomes small according to the other side caudad], and that lower limit extends to near the silicon melt 2 front face. Moreover, the upper limit of the thermal shield member 6 is laid in the upper limit of a heat insulating mould 9, and the radiant heat irradiated by the silicon single crystal rod 5 from a heater 8 by this thermal shield member 6 is intercepted. Furthermore, if inert gas is supplied in a chamber 1 with the gas feeding-and-discarding means (not shown) connected to the chamber 1, this inert gas will flow down the peripheral face of the silicon single crystal rod 5, as a two-dot chain line arrow head shows, and will be discharged out of the quartz crucible 3 through the clearance between thermal shield member 6 lower limit and silicon melt 2 front face.
[0003] Thus, although the oxygen in silicon melt 2 serves as SiO gas etc. and evaporates with the constituted equipment, in order that inert gas may flow the clearance between thermal shield member 6 lower limit and silicon melt 2 front face with sufficient vigor toward a quartz crucible 3 inner-skin side from a silicon single crystal rod 5 peripheral-face side by existence of the thermal shield member 6 at this time, emissions, such as SiO gas which carried out [above-mentioned] evaporation, are kept away from the silicon single crystal rod 5. Consequently, it can prevent that the above-mentioned emission is incorporated by the silicon single crystal rod 5, and the rearrangement which is a lattice defect occurs on the silicon single crystal rod 5. Moreover, since the thermal shield member 6 covers heat efficiently, it can improve the productivity of the silicon single crystal rod 5.
[0004]
[Problem(s) to be Solved by the Invention] However, with the pull-up equipment of the above-mentioned conventional silicon single crystal, an impurity may be generated from the member located more nearly up than the silicon single crystal rod which can be pulled up from silicon melt, this impurity mixed in inert gas, and was conveyed to the peripheral face of a silicon single crystal rod, and there was a possibility that a silicon single crystal rod might be polluted with this impurity. The purpose of this invention can prevent contamination of the silicon single crystal rod by the impurity mixed in inert gas, and is to offer the pull-up equipment of the silicon single crystal which can obtain the silicon single crystal rod of a high grade.
[0005]
[Means for Solving the Problem] The quartz crucible 13 with which it was prepared in the chamber 11 and silicon melt 12 was stored as invention concerning claim 1 was shown in drawing 1 and drawing 3 , The heater 18 which surrounds the peripheral face of the quartz crucible 13 and heats silicon melt 12, The thermal shield member 26 which surrounds the peripheral face of the silicon single crystal rod 25 which can be pulled up from silicon melt 12, and a lower limit opens spacing from silicon melt 12 front face, is located up, and interrupts the radiant heat from a heater 18, It is amelioration of the pull-up equipment of the silicon single crystal equipped with a gas feeding-and-discarding means 27 to make flow down inert gas between

the silicon single crystal rod 25 and the thermal shield member 26, and to make pass through silicon melt 12 front face, and to discharge out of a chamber 11. The place equipped with an impure gas discharge means 28 to attract the inert gas which flows down along the front face of the thermal shield member 26 among the inert gas which flows down between the silicon single crystal rod 25 and the thermal shield member 26, and to discharge out of a chamber 11 has the characteristic configuration. With the pull-up equipment of the silicon single crystal indicated by this claim 1, the impurity generated from the member of the upper part in a chamber 11 may mix in the inert gas supplied in the chamber 11 by the gas feeding-and-discarding means 27, it rides and flows down with the flow of the inert gas along the member front face of the upper part in a chamber 11, and this impurity flows down along with thermal shield member 26 inner skin further. Since the inert gas containing this impurity is discharged out of a chamber 11 by the impure gas discharge means 28 before it approaches the silicon single crystal rod 25, the silicon single crystal rod 25 is hardly polluted with an impurity.

[0006] As invention concerning claim 2 is invention concerning claim 1 and it is further shown in drawing 1 Cavernous section 26c by which the impure gas discharge means 28 was formed in the thermal shield member 26, Two or more impure gas suction hole 26e opened for free passage and formed in 26d of inner circle walls of the thermal shield member 26 at cavernous section 26c, It is characterized by having 26f of impure gas discharge holes opened for free passage and formed in the upper part of the thermal shield member 26 at cavernous section 26c, and the aspirator which was formed out of the chamber 11 and connected to 26f of impure gas discharge holes through impure gas discharge pipe 28a. With the pull-up equipment of the silicon single crystal indicated by this claim 2, the inert gas containing the impurity which flows down along with thermal shield member 26 inner skin is attracted from impure gas suction hole 26e formed in 26d of inner circle walls of the thermal shield member 26, and is discharged out of a chamber 11 through cavernous section 26c of the thermal shield member 26, 26f of impure gas discharge holes, and impure gas discharge pipe 28a.

[0007] Invention concerning claim 3 is invention concerning claim 1, and as further shown in drawing 4 , it is characterized by having impure gas suction pipe 58a which the impure gas discharge means 58 is arranged by the inner skin of the thermal shield member 56, and has two or more impure gas suction hole 58b, and the aspirator which it was prepared out of the chamber 11 and connected with impure gas suction pipe 58a. With the pull-up equipment of the silicon single crystal indicated by this claim 3, the inert gas containing the impurity which flows down along with thermal shield member 56 inner skin is attracted from impure gas suction hole 58b, and is discharged out of a chamber 11 through impure gas suction pipe 58a.

[0008]

[Embodiment of the Invention] Next, the gestalt of operation of the 1st of this invention is explained based on a drawing. As shown in drawing 1 - drawing 3 , in the chamber 11 of the pull-up equipment 10 of a silicon single crystal, the quartz crucible 13 which stores silicon melt 12 is formed, and the external surface of this quartz crucible 13 is covered with the graphite susceptor 14. The inferior surface of tongue of the quartz crucible 13 is fixed to the upper limit of a pivot 16 through the above-mentioned graphite susceptor 14, and the lower part of this pivot 16 is connected to the crucible driving means 17 (drawing 3). The crucible driving means 17 is movable in the vertical direction while it has the 1st diversion motor made to rotate the quartz crucible 13 and the motor for rise and fall which makes it go up and down the quartz crucible 13 and the quartz crucible 13 may rotate in the predetermined direction by these motors, although not illustrated. The heater 18 which opens predetermined spacing and surrounds the peripheral face of this quartz crucible 13 to a way outside the quartz crucible 13 is formed, and the heat insulating mould 19 which opens predetermined spacing and surrounds the peripheral face of this heater 18 is formed in a way outside a heater 18. The silicon polycrystal of a high grade fed into the quartz crucible 13 at the heater 18 fuses, and it becomes silicon melt 12.

[0009] Moreover, the casing 21 of the shape of a cylinder of a minor diameter is formed in the top face of a chamber 11 from a chamber 11 (drawing 3). It pulls up to this casing 21, and a means 22 is established. The pull-up means 22 is established the 2nd diversion motor (not shown) which was formed in the upper limit section of casing 21 possible [revolution] in the level condition and which pulls up and is made to rotate a head (not shown) and this head, the wire cable 23 which hung toward the center of rotation of the quartz crucible 13 from the head, and in the above-mentioned head, and has rolling up or a motor for delivery ******** (not shown) for the wire cable 23. The seed crystal 24 for dipping in silicon melt 12 in the lower limit of the wire cable 23, and pulling up the silicon single crystal rod 25 is attached.

[0010] Between the peripheral face of the silicon single crystal rod 25, and the inner skin of the quartz crucible 13, the thermal shield member 26 is inserted so that the peripheral face of the silicon single crystal

rod 25 may be surrounded (drawing 1 and drawing 3). The thermal shield member 26 is formed with a graphite, and it has disc-like flange 26b jutted out over an abbreviation horizontal direction in the method of outside from the upper limit of tubed tubed part 26a to which a diameter becomes small according to the other side caudad, and this tubed part 26a (drawing 1 - drawing 3). The lower limit of tubed part 26a extends to near the silicon melt 12 front face, and upper limit is prolonged until it serves as upper limit of a heat insulating mould 19, and abbreviation same height. If the inferior surface of tongue of flange 26b of the above-mentioned thermal shield member 26 is installed in the top face of a heat insulating mould 19, the radiant heat which tubed part 26a of the thermal shield member 26 divides to the end-crater inner skin side which takes the inside of a chamber 11 a silicon single crystal side, and is irradiated by the silicon single crystal rod 25 from a heater 18 will be intercepted (drawing 1 and drawing 3).

[0011] A gas feeding-and-discarding means 27 to make a chamber 11 flow down inert gas, such as argon gas and nitrogen gas, between the silicon single crystal rod 25 and the thermal shield member 26, and to make pass through silicon melt 12 front face, and to discharge out of a chamber 11 is connected (drawing 3). The gas feeding-and-discarding means 27 has gas supply pipe 27a by which the end was connected to the up peripheral wall of casing 21, and the other end was connected to the air tank (not shown), and gas discharge pipe 27b by which the end was connected to the low wall of a chamber 11, and the other end was connected to the vacuum pump (not shown). The 1st and 2nd flow control valves 27c and 27d which adjust the flow rate of the inert gas which flows these pipes 27a and 27b are formed in gas supply pipe 27a and gas discharge pipe 27b, respectively.

[0012] The place equipped with an impure gas discharge means 28 to attract the inert gas which flows down along the front face of the thermal shield member 26 among the inert gas which flows down between the silicon single crystal rod 25 and the thermal shield member 26, and to discharge out of a chamber 11 has the characteristic configuration of the gestalt of this operation (drawing 1 - drawing 3). Cavernous section 26c by which the impure gas discharge means 28 was formed in the thermal shield member 26, Two or more impure gas suction hole 26e opened for free passage and formed in 26d of inner circle walls of the thermal shield member 26 at cavernous section 26c, It has 26f of impure gas discharge holes opened for free passage and formed in the upper part of the thermal shield member 26 at cavernous section 26c, and the aspirator (not shown) which was formed out of the chamber 11 and connected to 26f of impure gas discharge holes through impure gas discharge pipe 28a. Cavernous section 26c is formed over tubed part 26a of the thermal shield member 26, and the whole flange 26b, and two or more impure gas suction hole 26e is formed in 26d of inner circle walls of tubed part 26a.

[0013] Moreover, two or more impure gas suction hole 26e is formed, respectively in the shape of [which is prolonged in the circumferencial direction of 26d of inner circle walls of tubed part 26a] a slit, as shown in drawing 2 in detail. These slit-like impure gas suction hole 26e opens predetermined spacing on the same periphery of 26d of inner circle walls of tubed part 26a, and opens predetermined spacing in the pull-up direction of the silicon single crystal rod 25, and is formed, respectively. As for impure gas suction hole 26e which adjoin up and down among two or more impure gas suction holes, it is desirable to shift to the circumferencial direction of 26d of inner circle walls mutually, and to form in it. Moreover, 26f of impure gas discharge holes is formed in 26g of upper walls of flange 26b, and impure quantity-of-gas-flow regulator-valve 28b which adjusts the flow rate of the inert gas in this pipe 28a is prepared in impure gas discharge pipe 28a. Furthermore, a vacuum pump may be used as an aspirator and the vacuum pump connected to gas discharge pipe 27b of the above-mentioned gas feeding-and-discarding means 28 is sufficient as this vacuum pump. In addition, not a slit-like hole but a circular hole or the hole of other configurations is sufficient as an impure gas inhalation hole.

[0014] In addition, as for the flow rate of the inert gas supplied in a chamber 11 from gas supply pipe 27a, it is desirable that it is [20-60l.] a part for part further 30-40l./for /. Moreover, as for the suction flow rate of the inert gas attracted from gas discharge pipe 27b, it is desirable that it is [10-50l.] a part for part further 20-30l./for /, and, as for the suction flow rate of the inert gas attracted from impure gas suction hole 26e, it is desirable that it is [2-20l.] a part for part further 5-10l./for /. As for the pressure of the inert gas in a chamber 11, it is desirable that they are 0.014-0.041kg/cm2 and further 0.016-0.027kg/cm2 near the feed hopper of this inert gas.

[0015] A rotary encoder (not shown) is connected to the output shaft (not shown) of the motor for a pull-up, and the weight sensor (not shown) which detects the weight of the silicon melt 12 in the quartz crucible 13, and the linear encoder (not shown) which detects the rise-and-fall location of a pivot 16 are formed in the crucible driving means 17. Each detection output of a rotary encoder, a weight sensor, and a linear encoder is connected to the control input of a controller (not shown), and the control output of a controller is

connected to the motor for a pull-up of the pull-up means 22, and the motor for rise and fall of the crucible driving means 17, respectively. Moreover, memory (not shown) is prepared in a controller, the rolling-up die length of the wire cable 23 to the detection output of a rotary encoder, i.e., the pull-up die length of the silicon single crystal rod 25, is memorized by this memory as a map, and the oil-level level of the silicon melt 12 in the quartz crucible 13 to the detection output of a weight sensor is memorized as a map. A controller controls the motor for rise and fall of the crucible driving means 17 so that the oil level of the silicon melt 12 in the quartz crucible 13 always maintains at fixed level based on the detection output of a weight sensor.

[0016] Thus, actuation of the pull-up equipment of the constituted silicon single crystal is explained. When pulling up the silicon single crystal rod 25, the flow rate of the inert gas which passes through between silicon melt 12 front face and thermal shield member 26 lower limits, and the flow rate of the inert gas attracted from impure gas suction hole 26e are adjusted, respectively by adjusting the 1st and 2nd flow control valves 27c and 7d and impure quantity-of-gas-flow regulator-valve 28b.

[0017] Moreover, the impurity of heavy metal, such as iron generated from the member of the upper part in a chamber 11 and copper, may mix in the inert gas supplied in the chamber 11 from gas supply pipe 27a. It rides and flows down with the flow of the inert gas along the member front face of the upper part in a chamber 11, and this impurity flows down along with the tubed part 26a inner skin of the thermal shield member 26 further. The inert gas which contains the above-mentioned impurity from impure gas suction hole 26e formed in 26d of inner circle walls of the thermal shield member 26 at this time, i.e., impure gas, is attracted, it is discharged out of a chamber 11 through cavernous section 26a of the thermal shield member 26, 26f of impure gas discharge holes, and impure gas discharge pipe 28a, namely, before impure gas approaches the silicon single crystal rod 25, it is discharged out of a chamber 11. Consequently, since the inert gas of silicon single crystal rod 25 perimeter which can be pulled up from silicon melt 12 does not almost have that the above-mentioned silicon single crystal rod 25 is polluted with an impurity, hardly including an impurity, the silicon single crystal rod 25 of a high grade can be manufactured.

[0018] Drawing 4 - drawing 6 show the gestalt of operation of the 2nd of this invention. In drawing 4 and drawing 6 , the same sign as drawing 1 and drawing 3 shows the same components. With this equipment, it has impure gas suction pipe 58a in which the impure gas discharge means 58 was arranged by the inner skin of the thermal shield member 56, and the aspirator (not shown) connected to impure gas suction pipe 58a. The thermal shield member 56 is formed with a graphite, and it has disc-like flange 56b jutted out over an abbreviation horizontal direction in the method of outside from the upper limit of tubed tubed part 56a to which a diameter becomes small according to the other side caudad, and this tubed part 56a (drawing 4 - drawing 6). Tubed part 56a and flange 56b are formed in the tubed part and flange, and abbreviation same configuration of a gestalt of the 1st operation except for not having the cavernous section like the tubed part of the gestalt of implementation of the above 1st, and a flange.

[0019] Impure gas suction pipe 58a is the single pipe formed in the shape of a ring with the graphite, and is horizontally arranged along with the inner skin of tubed part 56a. Moreover, predetermined spacing is opened in impure gas suction pipe 58a, and two or more impure gas suction hole 58b is formed. The same equipment as the aspirator of the gestalt of the 1st operation is used, and an aspirator is formed out of a chamber 11. Impure gas suction pipe 58a is connected to an aspirator through impure gas discharge pipe 58c, and impure gas discharge pipe 58c also plays the role holding impure gas suction pipe 58a. Moreover, impure quantity-of-gas-flow regulator-valve 28b is prepared in impure gas discharge pipe 58c. It is constituted identically to the gestalt of the 1st operation except the above.

[0020] Thus, with the pull-up equipment of the constituted silicon single crystal, except for the impure gas (inert gas containing an impurity) which flows down along with the tubed part 56a inner skin of the thermal shield member 56 being attracted from impure gas suction hole 58b, and being discharged out of a chamber 11 through impure gas suction pipe 58a and impure gas discharge pipe 58c, since actuation is the same as that of the gestalt of implementation of the above 1st, and abbreviation, explanation of a repetition is omitted. Moreover, unlike the gestalt of the 1st operation, the impure gas discharge means 58 of the gestalt of this operation can be added to the ready-made thermal shield member 56, and can be established. In addition, although the single impure gas suction pipe was arranged along with the tubed part inner skin of a thermal shield member with the gestalt of this operation, two or more impure gas suction pipes may be arranged along with the tubed part inner skin of a thermal shield member.

[0021]

[Example] Next, the example of this invention is explained in detail with the example of a comparison. As shown in <example 1> drawing 1 - drawing 3 , the thermal shield member 26 made from a graphite

which has cavernous section 26c was inserted into the chamber 11, the upper wall of this thermal shield member 26 was installed in the top face of a heat insulating mould 19, and argon gas was supplied to 11 in a chamber by the 30l. flow rate for /from gas supply pipe 27a by adjusting 1st flow control valve 27c. Moreover, by adjusting the 27d of the 2nd flow control valve, the argon gas in a chamber 11 was attracted by the 25l. flow rate for /from gas discharge pipe 27b, and the argon gas which flows down tubed part 26a inner skin was attracted by part for 5l./from impure gas suction hole 26e by adjusting impure quantity-of-gas-flow regulator-valve 28b. The pressure of the inert gas in a chamber 11 was 0.020kg/cm2 near the feed hopper of this inert gas. The bore of the above-mentioned quartz crucible 13 was 400mm, and the weight of the silicon melt 12 stored by this quartz crucible 13 was 40kg. The bores of the upper limit of tubed part 26a of the thermal shield member 26 and a lower limit were 350mm and 200mm, respectively, and the height of tubed part 26a was 300mm. Moreover, the width of face and die length of each impure gas suction hole 26e were 10mm and 50mm, respectively, and these numbers were 24 pieces. Furthermore, the distance between a tubed part 26a lower limit and silicon melt 12 front face was 25mm.

[0022] As shown in <example 2> drawing 4 - drawing 6 , the thermal shield member 56 made from a graphite without the cavernous section was inserted so that the peripheral face of the silicon single crystal rod 25 might be surrounded between silicon single crystal rod 25 peripheral face and quartz crucible 13 inner skin, and single impure gas suction pipe 58a was arranged along with the tubed part 56a inner skin of this thermal shield member 56. Argon gas was supplied to 11 in a chamber by the 30l. flow rate for /from gas supply pipe 27a by adjusting 1st flow control valve 27c. Moreover, by adjusting the 27d of the 2nd flow control valve, the argon gas in a chamber 11 was attracted by the 25l. flow rate for /from gas discharge pipe 27b, and the argon gas which flows down tubed part 56a inner skin was attracted by part for 5l./from impure gas suction hole 58b by adjusting impure quantity-of-gas-flow regulator-valve 28b. The pressure of the inert gas in a chamber 11 was 0.020kg/cm2 near the feed hopper of this inert gas. The dimension of the thermal shield member 56 was the dimension and abbreviation identitas of a thermal shield member of an example 1, and the ring bore of impure gas suction pipe 58a and the bore of the pipe 58a itself were 200mm and 15mm, respectively. Moreover, 12 impure with a diameter of 5mm gas suction hole 58b was formed in impure gas suction pipe 58a. Furthermore, impure gas suction pipe 58a was arranged in 60mm upper part from the lower limit of tubed part 56a. It constituted identically to an example 1 except the above.

[0023] As shown in <example 1 of comparison> drawing 7 , the thermal shield member 6 of the same configuration as an example 2 was inserted so that the silicon single crystal rod 5 might be surrounded between the peripheral face of the silicon single crystal rod 5, and the inner skin of the quartz crucible 3, argon gas was supplied by the 30l. flow rate for /in the chamber 1 from the gas supply pipe (not shown), and the argon gas in a chamber 1 was attracted by the 30l. flow rate for /from the gas discharge pipe (not shown). The pressure of the inert gas in a chamber 1 was 0.020kg/cm2 near the feed hopper of this inert gas. Moreover, the impure gas suction pipe of an example 2 was not used. It constituted identically to an example 2 except the above.

[0024] After manufacturing the silicon single crystal rod whose diameter is 150mm with the equipment of the example 1 of a comparison in the <comparative study and evaluation> example 1 and example 2 list, these silicon single crystal rods were sliced in thickness of 2mm, the part which corresponds near the periphery of a crystal was chosen and cut, and the tabular sample was created, respectively. After carrying out mirror etching of the front face of these samples with the mixed acid and going heat treatment for an oxygen donor's elimination, the concentration of Fe, Mo, and Cu inside each test piece was measured by the DLTS (Deep level transient spectroscopy) method, respectively. This measurement result is shown in Table 1. In addition, the measuring point of the above-mentioned concentration was taken as the part which is equivalent to about 5mm inside from a crystal periphery.

[0025]

[Table 1]

	Fe濃度 (cm^{-3})	Mo濃度 (cm^{-3})	Cu濃度 (cm^{-3})
実施例1	$<10^{10}$	$<10^{10}$	$<10^{10}$
実施例2	$<10^{10}$	$<10^{10}$	$<10^{10}$
比較例1	5.5×10^{11}	1.0×10^{12}	2.5×10^{11}

[0026] clear from Table 1 -- as -- an example 1 and an example 2 -- metal high impurity concentration -- DLTS -- it is below the minimum limit of detection of law, and the crystal of the high grade which does not have almost contamination as compared with the example 1 of a comparison was able to be obtained.
[0027]
[Effect of the Invention] Since it constituted according to this invention so that an impure gas discharge means might attract the inert gas containing the impurity which flows down along the front face of a thermal shield member among the inert gas which flows down between a silicon single crystal rod and a thermal shield member and it might be discharged out of a chamber before approaching a silicon single crystal rod as stated above, the inert gas of the perimeter of a silicon single crystal rod does not almost have that the above-mentioned silicon single crystal rod is polluted with an impurity, hardly including an impurity. Consequently, the silicon single crystal rod of a high grade can be manufactured. Moreover, form the cavernous section in a thermal shield member, and it is open for free passage to the inner circle wall of a thermal shield member at the cavernous section, and two or more impure gas suction holes are formed. If the aspirator which was open for free passage in the cavernous section, formed the impure gas discharge hole in the upper part of a thermal shield member, and was further formed out of the chamber is connected to an impure gas discharge hole through an impure gas discharge pipe Since the inert gas containing the impurity which flows down along with thermal shield member inner skin is attracted from an impure gas suction hole and it is discharged out of a chamber through the cavernous section, an impure gas discharge hole, and an impure gas discharge pipe, the same effectiveness as the above is acquired. Furthermore, since the impure gas suction pipe which has two or more impure gas suction holes is arranged in the inner skin of a thermal shield member, the inert gas which contains the impurity which flows down along with thermal shield member inner skin if the aspirator formed out of the chamber is connected to an impure gas suction pipe is attracted from an impure gas suction hole and it is discharged out of a chamber through an impure gas suction pipe, the same effectiveness as the above is done so.

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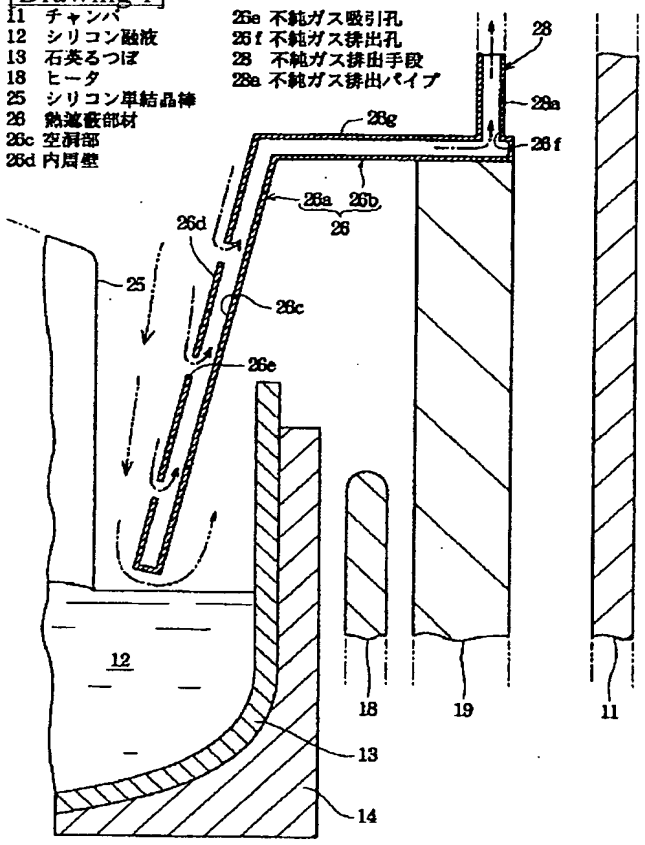
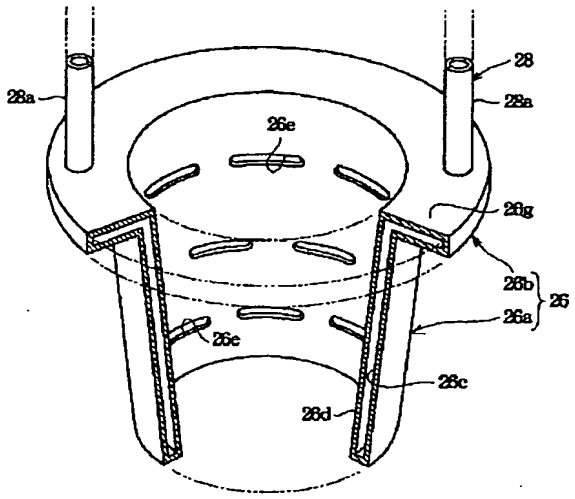
DRAWINGS

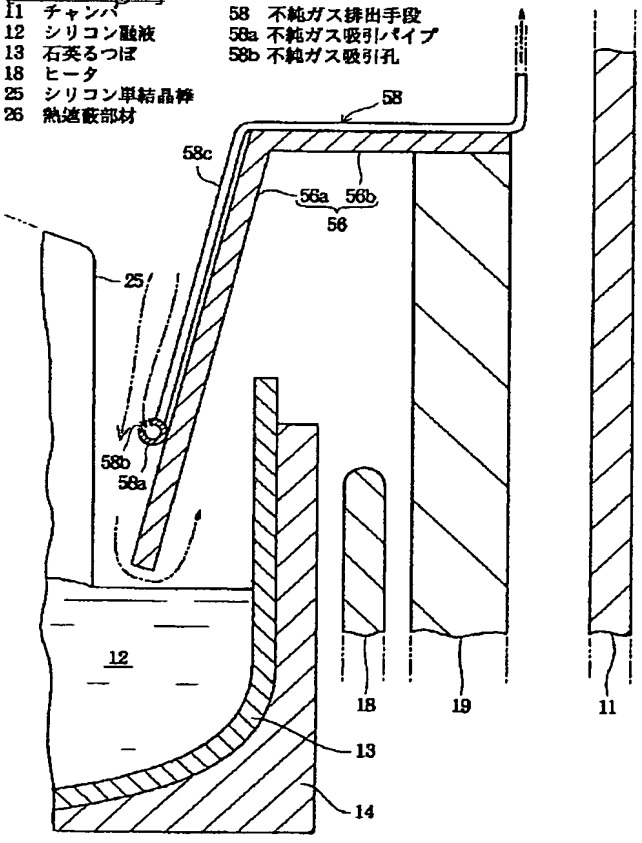
[Drawing 1]



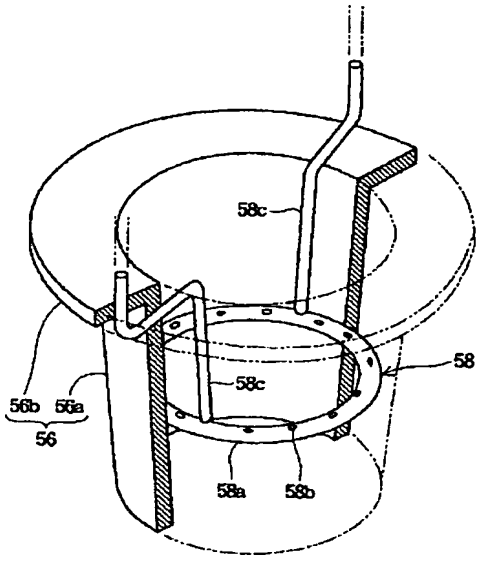
[Drawing 2]



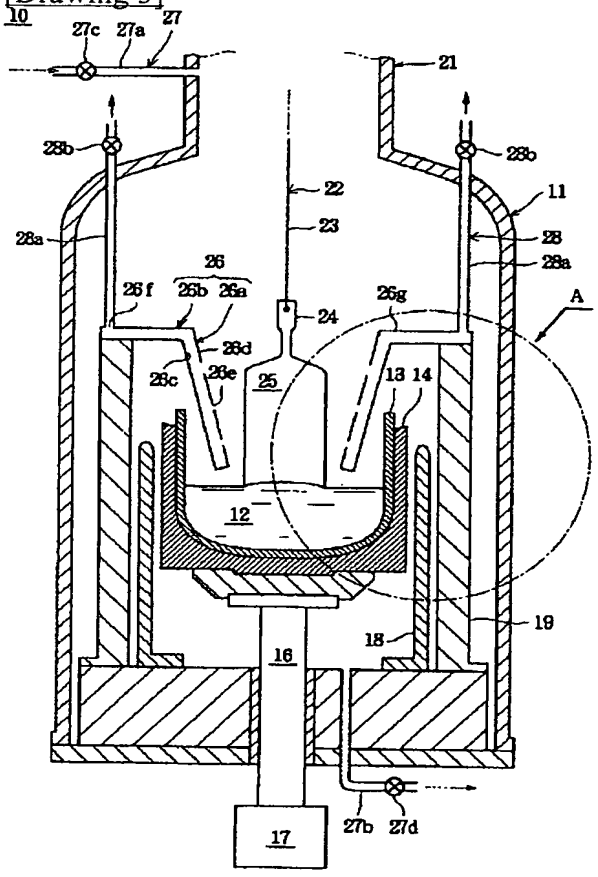
[Drawing 4]



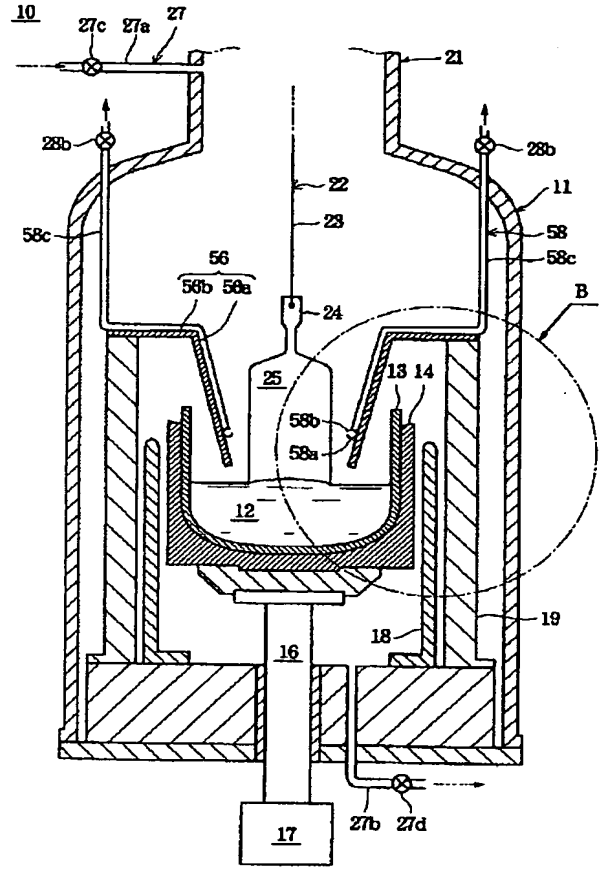
[Drawing 5]



[Drawing 3]



[Drawing 6]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27c
27a
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11
58c
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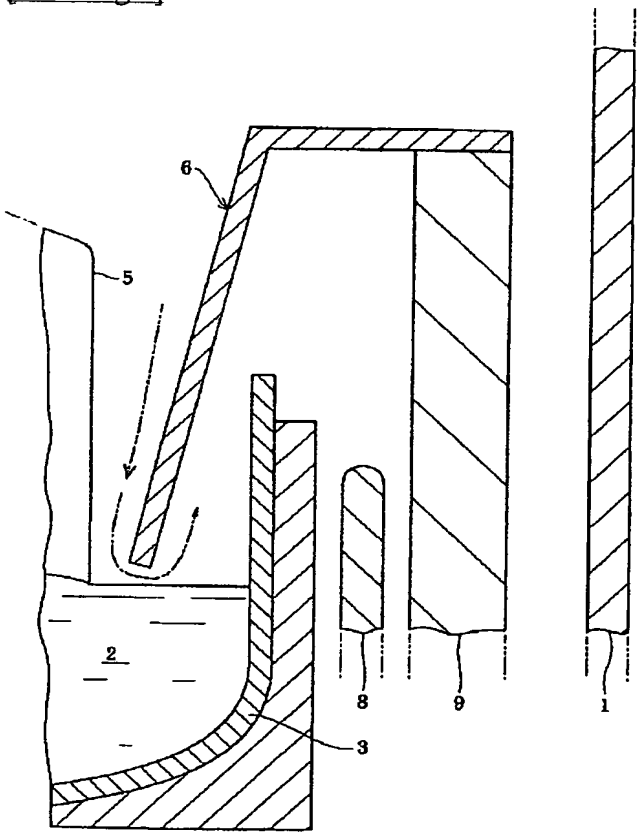
27d

[Drawing 7]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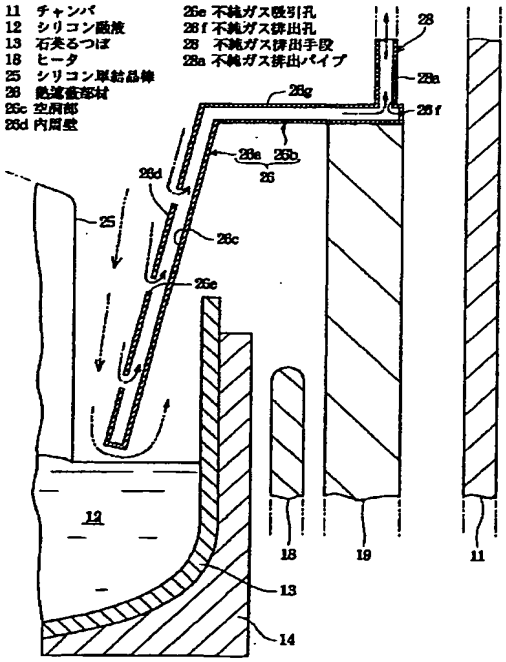
(54)【発明の名称】　シリコン単結晶の引上げ装置

(57)【要約】
【課題】不活性ガスに混入した不純物によるシリコン単結晶棒の汚染を防止でき、高純度のシリコン単結晶棒を得ることができる。
【解決手段】チャンバ１１内に設けられた石英るつぼ１３にシリコン融液１２が貯留され、石英るつぼ１３の外周面を包囲するヒータ１８がシリコン融液１２を加熱する。シリコン融液１２から引上げられるシリコン単結晶棒２５の外周面を包囲しかつ下端がシリコン融液１２表面から間隔をあけて上方に位置する熱遮蔽部材２６がヒータ１８からの輻射熱を遮り、ガス給排手段が不活性ガスをシリコン単結晶棒２５及び熱遮蔽部材２６間を流下させかつシリコン融液１２表面を通過させてチャンバ１１外に排出する。不純ガス排出手段２８がシリコン単結晶棒２５及び熱遮蔽部材２６間を流下する不活性ガスのうち熱遮蔽部材２６の表面に沿って流下する不活性ガスを吸引してチャンバ１１外に排出する。



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【特許請求の範囲】

【請求項１】　チャンバ(11)内に設けられシリコン融液(12)が貯留された石英るつぼ(13)と、前記石英るつぼ(13)の外周面を包囲し前記シリコン融液(12)を加熱するヒータ(18)と、前記シリコン融液(12)から引上げられるシリコン単結晶棒(25)の外周面を包囲しかつ下端が前記シリコン融液(12)表面から間隔をあけて上方に位置し前記ヒータ(18)からの輻射熱を遮る熱遮蔽部材(26,56)と、不活性ガスを前記シリコン単結晶棒(25)及び前記熱遮蔽部材(26,56)間を流下させかつ前記シリコン融液(12)表面を通過させて前記チャンバ(11)外に排出するガス給排手段(27)とを備えたシリコン単結晶の引上げ装置において、

前記シリコン単結晶棒(25)及び前記熱遮蔽部材(26,56)間を流下する不活性ガスのうち前記熱遮蔽部材(26,56)の表面に沿って流下する前記不活性ガスを吸引して前記チャンバ(11)外に排出する不純ガス排出手段(28,58)を備えたことを特徴とするシリコン単結晶の引上げ装置。

【請求項２】　不純ガス排出手段(28)が熱遮蔽部材(26)内に形成された空洞部(26c)と、前記熱遮蔽部材(26)の内周壁(26d)に前記空洞部(26c)に連通して形成された複数の不純ガス吸引孔(26e)と、前記熱遮蔽部材(26)の上部に前記空洞部(26c)に連通して形成された不純ガス排出孔(26f)と、チャンバ(11)外に設けられ前記不純ガス排出孔(26f)に不純ガス排出パイプ(28a)を介して接続された吸引装置とを有する請求項１記載のシリコン単結晶の引上げ装置。

【請求項３】　不純ガス排出手段(58)が熱遮蔽部材(56)の内周面に配設され複数の不純ガス吸引孔(58b)を有する不純ガス吸引パイプ(58a)と、チャンバ(11)外に設けられ前記不純ガス吸引パイプ(58a)に接続された吸引装置とを有する請求項１記載のシリコン単結晶の引上げ装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、シリコン単結晶棒を引上げて育成する装置に関するものである。

【０００２】

【従来の技術】従来、この種の装置として、図７に示すように、チャンバ１内にシリコン融液２が貯留された石英るつぼ３が収容され、シリコン単結晶棒５の外周面と石英るつぼ３の内周面との間にシリコン単結晶棒５を囲むように熱遮蔽部材６が挿入され、更に熱遮蔽部材６の上端が外方に略水平方向に張り出されたものが知られている。この装置では、熱遮蔽部材６は下方に向うに従って直径が小さくなる筒状に形成され、その下端はシリコン融液２表面近傍まで延びる。また熱遮蔽部材６の上端は保温筒９の上端に載置され、この熱遮蔽部材６によりヒータ８からシリコン単結晶棒５に照射される輻射熱が遮断される。更にチャンバ１に接続されたガス給排手段

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（図示せず）によりチャンバ１内に不活性ガスを供給すると、この不活性ガスは二点鎖線矢印で示すようにシリコン単結晶棒５の外周面を流下し、熱遮蔽部材６下端及びシリコン融液２表面の隙間を通って石英るつぼ３外に排出されるようになっている。

【０００３】このように構成された装置では、シリコン融液２中の酸素がＳｉＯガス等となって蒸発するが、このとき熱遮蔽部材６の存在により不活性ガスが熱遮蔽部材６下端及びシリコン融液２表面の隙間をシリコン単結晶棒５外周面側から石英るつぼ３内周面側に向って勢い良く流れるため、上記蒸発したＳｉＯガス等の蒸発物をシリコン単結晶棒５から遠ざける。この結果、上記蒸発物がシリコン単結晶棒５に取り込まれてシリコン単結晶棒５に格子欠陥である転位が発生するのを防止できる。また熱遮蔽部材６は熱を効率よく遮蔽するため、シリコン単結晶棒５の生産性を向上できるようになっている。

【０００４】

【発明が解決しようとする課題】しかし、上記従来のシリコン単結晶の引上げ装置では、シリコン融液から引上げられるシリコン単結晶棒よりも上方に位置する部材から不純物が発生する場合があり、この不純物が不活性ガスに混入してシリコン単結晶棒の外周面まで搬送され、この不純物によりシリコン単結晶棒が汚染される恐れがあった。本発明の目的は、不活性ガスに混入した不純物によるシリコン単結晶棒の汚染を防止でき、高純度のシリコン単結晶棒を得ることができるシリコン単結晶の引上げ装置を提供することにある。

【０００５】

【課題を解決するための手段】請求項１に係る発明は、図１及び図３に示すように、チャンバ１１内に設けられシリコン融液１２が貯留された石英るつぼ１３と、石英るつぼ１３の外周面を包囲しシリコン融液１２を加熱するヒータ１８と、シリコン融液１２から引上げられるシリコン単結晶棒２５の外周面を包囲しかつ下端がシリコン融液１２表面から間隔をあけて上方に位置しヒータ１８からの輻射熱を遮る熱遮蔽部材２６と、不活性ガスをシリコン単結晶棒２５及び熱遮蔽部材２６間を流下させかつシリコン融液１２表面を通過させてチャンバ１１外に排出するガス給排手段２７とを備えたシリコン単結晶の引上げ装置の改良である。その特徴ある構成は、シリコン単結晶棒２５及び熱遮蔽部材２６間を流下する不活性ガスのうち熱遮蔽部材２６の表面に沿って流下する不活性ガスを吸引してチャンバ１１外に排出する不純ガス排出手段２８を備えたところにある。この請求項１に記載されたシリコン単結晶の引上げ装置では、ガス給排手段２７によりチャンバ１１内に供給された不活性ガスにはチャンバ１１内上部の部材から発生した不純物が混入する場合があり、この不純物はチャンバ１１内上部の部材表面に沿う不活性ガスの流れに乗って流下し、更に熱遮蔽部材２６内周面に沿って流下する。この不純物を含

む不活性ガスはシリコン単結晶棒２５に接近する前に不純ガス排出手段２８によりチャンバ１１外に排出されるので、シリコン単結晶棒２５が不純物により汚染されることは殆どない。

【０００６】請求項２に係る発明は、請求項１に係る発明であって、更に図１に示すように、不純ガス排出手段２８が熱遮蔽部材２６内に形成された空洞部２６ｃと、熱遮蔽部材２６の内周壁２６ｄに空洞部２６ｃに連通して形成された複数の不純ガス吸引孔２６ｅと、熱遮蔽部材２６の上部に空洞部２６ｃに連通して形成された不純ガス排出孔２６ｆと、チャンバ１１外に設けられ不純ガス排出孔２６ｆに不純ガス排出パイプ２８ａを介して接続された吸引装置とを有することを特徴とする。この請求項２に記載されたシリコン単結晶の引上げ装置では、熱遮蔽部材２６内周面に沿って流下する不純物を含む不活性ガスは熱遮蔽部材２６の内周壁２６ｄに形成された不純ガス吸引孔２６ｅから吸引され、熱遮蔽部材２６の空洞部２６ｃ、不純ガス排出孔２６ｆ及び不純ガス排出パイプ２８ａを通ってチャンバ１１外に排出される。

【０００７】請求項３に係る発明は、請求項１に係る発明であって、更に図４に示すように、不純ガス排出手段５８が熱遮蔽部材５６の内周面に配設され複数の不純ガス吸引孔５８ｂを有する不純ガス吸引パイプ５８ａと、チャンバ１１外に設けられ不純ガス吸引パイプ５８ａに接続された吸引装置とを有することを特徴とする。この請求項３に記載されたシリコン単結晶の引上げ装置では、熱遮蔽部材５６内周面に沿って流下する不純物を含む不活性ガスは不純ガス吸引孔５８ｂから吸引され、不純ガス吸引パイプ５８ａを通ってチャンバ１１外に排出される。

【０００８】

【発明の実施の形態】次に本発明の第１の実施の形態を図面に基づいて説明する。図１～図３に示すように、シリコン単結晶の引上げ装置１０のチャンバ１１内には、シリコン融液１２を貯留する石英るつぼ１３が設けられ、この石英るつぼ１３の外面は黒鉛サセプタ１４により被覆される。石英るつぼ１３の下面は上記黒鉛サセプタ１４を介して支軸１６の上端に固定され、この支軸１６の下部はるつぼ駆動手段１７に接続される（図３）。るつぼ駆動手段１７は図示しないが石英るつぼ１３を回転させる第１回転用モータと、石英るつぼ１３を昇降させる昇降用モータとを有し、これらのモータにより石英るつぼ１３が所定の方向に回転し得るとともに、上下方向に移動可能となっている。石英るつぼ１３の外方にはこの石英るつぼ１３の外周面を所定の間隔をあけて包囲するヒータ１８が設けられ、ヒータ１８の外方にはこのヒータ１８の外周面を所定の間隔をあけて包囲する保温筒１９が設けられる。ヒータ１８により石英るつぼ１３に投入された高純度のシリコン多結晶が溶融してシリコン融液１２になる。

【０００９】またチャンバ１１の上面にはチャンバ１１より小径の円筒状のケーシング２１が設けられる（図３）。このケーシング２１には引上げ手段２２が設けられる。引上げ手段２２はケーシング２１の上端部に水平状態で旋回可能に設けられた引上げヘッド（図示せず）と、このヘッドを回転させる第２回転用モータ（図示せず）と、ヘッドから石英るつぼ１３の回転中心に向って垂下されたワイヤケーブル２３と、上記ヘッド内に設けられワイヤケーブル２３を巻取り又は繰出す引上げ用モータ（図示せず）とを有する。ワイヤケーブル２３の下端にはシリコン融液１２に浸してシリコン単結晶棒２５を引上げるための種結晶２４が取付けられる。

【００１０】シリコン単結晶棒２５の外周面と石英るつぼ１３の内周面との間にはシリコン単結晶棒２５の外周面を包囲するように熱遮蔽部材２６が挿入される（図１及び図３）。熱遮蔽部材２６は黒鉛により形成され、下方に向うに従って直径が小さくなる筒状の筒状部２６ａと、この筒状部２６ａの上端から外方に略水平方向に張り出す円板状のフランジ部２６ｂとを有する（図１～図３）。筒状部２６ａの下端はシリコン融液１２表面近傍まで延び、上端は保温筒１９の上端と略同一高さとなるまで延びる。上記熱遮蔽部材２６のフランジ部２６ｂの下面を保温筒１９の上面に設置すると、熱遮蔽部材２６の筒状部２６ａがチャンバ１１内をシリコン単結晶側とるつぼ内周面側とに区画しかつヒータ１８からシリコン単結晶棒２５に照射される輻射熱を遮断するようになっている（図１及び図３）。

【００１１】チャンバ１１にはアルゴンガスや窒素ガス等の不活性ガスをシリコン単結晶棒２５及び熱遮蔽部材２６間を流下させかつシリコン融液１２表面を通過させてチャンバ１１外に排出するガス給排手段２７が接続される（図３）。ガス給排手段２７は一端がケーシング２１の上部周壁に接続され他端がエアタンク（図示せず）に接続されたガス供給パイプ２７ａと、一端がチャンバ１１の下壁に接続され他端が真空ポンプ（図示せず）に接続されたガス排出パイプ２７ｂとを有する。ガス供給パイプ２７ａ及びガス排出パイプ２７ｂにはこれらのパイプ２７ａ，２７ｂを流れる不活性ガスの流量を調整する第１及び第２流量調整弁２７ｃ，２７ｄがそれぞれ設けられる。

【００１２】この実施の形態の特徴ある構成は、シリコン単結晶棒２５及び熱遮蔽部材２６間を流下する不活性ガスのうち熱遮蔽部材２６の表面に沿って流下する不活性ガスを吸引してチャンバ１１外に排出する不純ガス排出手段２８を備えたところにある（図１～図３）。不純ガス排出手段２８は熱遮蔽部材２６内に形成された空洞部２６ｃと、熱遮蔽部材２６の内周壁２６ｄに空洞部２６ｃに連通して形成された複数の不純ガス吸引孔２６ｅと、熱遮蔽部材２６の上部に空洞部２６ｃに連通して形成された不純ガス排出孔２６ｆと、チャンバ１１外に設

けられ不純ガス排出孔２６ｆに不純ガス排出パイプ２８ａを介して接続された吸引装置（図示せず）とを有する。空洞部２６ｃは熱遮蔽部材２６の筒状部２６ａ及びフランジ部２６ｂの全体にわたって形成され、複数の不純ガス吸引孔２６ｅは筒状部２６ａの内周壁２６ｄに形成される。

【００１３】また複数の不純ガス吸引孔２６ｅは図２に詳しく示すように、筒状部２６ａの内周壁２６ｄの円周方向に延びるスリット状にそれぞれ形成される。これらスリット状の不純ガス吸引孔２６ｅは筒状部２６ａの内周壁２６ｄの同一円周上に所定の間隔をあけかつシリコン単結晶棒２５の引上げ方向に所定の間隔をあけてそれぞれ形成される。複数の不純ガス吸引孔のうち上下に隣接する不純ガス吸引孔２６ｅ同士は内周壁２６ｄの円周方向に互いにずらして形成することが好ましい。また不純ガス排出孔２６ｆはフランジ部２６ｂの上壁２６ｇに形成され、不純ガス排出パイプ２８ａにはこのパイプ２８ａ内の不活性ガスの流量を調整する不純ガス流量調整弁２８ｂが設けられる。更に吸引装置としては真空ポンプが用いられ、この真空ポンプは上記ガス給排手段２８のガス排出パイプ２７ｂに接続された真空ポンプでもよい。なお、不純ガス吸入孔はスリット状の孔ではなく、円形孔又はその他の形状の孔でもよい。

【００１４】なお、ガス供給パイプ２７ａからチャンバ１１内に供給される不活性ガスの流量は２０～６０リットル／分、更に３０～４０リットル／分であることが好ましい。またガス排出パイプ２７ｂから吸引される不活性ガスの吸引流量は１０～５０リットル／分、更に２０～３０リットル／分であることが好ましく、不純ガス吸引孔２６ｅから吸引される不活性ガスの吸引流量は２～２０リットル／分、更に５～１０リットル／分であることが好ましい。チャンバ１１内の不活性ガスの圧力はこの不活性ガスの供給口付近で０．０１４～０．０４１ｋｇ／ｃｍ²、更に０．０１６～０．０２７ｋｇ／ｃｍ²であることが好ましい。

【００１５】引上げ用モータの出力軸（図示せず）にはロータリエンコーダ（図示せず）が接続され、るつぼ駆動手段１７には石英るつぼ１３内のシリコン融液１２の重量を検出する重量センサ（図示せず）と、支軸１６の昇降位置を検出するリニヤエンコーダ（図示せず）とが設けられる。ロータリエンコーダ、重量センサ及びリニヤエンコーダの各検出出力はコントローラ（図示せず）の制御入力に接続され、コントローラの制御出力は引上げ手段２２の引上げ用モータ、るつぼ駆動手段１７の昇降用モータにそれぞれ接続される。またコントローラにはメモリ（図示せず）が設けられ、このメモリにはロータリエンコーダの検出出力に対するワイヤケーブル２３の巻取り長さ、即ちシリコン単結晶棒２５の引上げ長さがマップとして記憶され、重量センサの検出出力に対する石英るつぼ１３内のシリコン融液１２の液面レベルがマップとして記憶される。コントローラは重量センサの検出出力に基づいて石英るつぼ１３内のシリコン融液１２の液面が常に一定のレベルに保つように、るつぼ駆動手段１７の昇降用モータを制御する。

【００１６】このように構成されたシリコン単結晶の引上げ装置の動作を説明する。シリコン単結晶棒２５を引上げるときには、第１及び第２流量調整弁２７ｃ，７ｄと不純ガス流量調整弁２８ｂとを調整することにより、シリコン融液１２表面と熱遮蔽部材２６下端との間を通過する不活性ガスの流量と不純ガス吸引孔２６ｅから吸引される不活性ガスの流量をそれぞれ調整する。

【００１７】またガス供給パイプ２７ａからチャンバ１１内に供給された不活性ガスにはチャンバ１１内上部の部材から発生した鉄や銅等の重金属の不純物が混入する場合がある。この不純物はチャンバ１１内上部の部材表面に沿う不活性ガスの流れに乗って流下し、更に熱遮蔽部材２６の筒状部２６ａ内周面に沿って流下する。このとき熱遮蔽部材２６の内周壁２６ｄに形成された不純ガス吸引孔２６ｅから上記不純物を含む不活性ガス、即ち不純ガスが吸引され、熱遮蔽部材２６の空洞部２６ａ、不純ガス排出孔２６ｆ及び不純ガス排出パイプ２８ａを通ってチャンバ１１外に排出される、即ち不純ガスがシリコン単結晶棒２５に接近する前にチャンバ１１外に排出される。この結果、シリコン融液１２から引上げられるシリコン単結晶棒２５周囲の不活性ガスは不純物を殆ど含まず、上記シリコン単結晶棒２５が不純物により汚染されることは殆どないので、高純度のシリコン単結晶棒２５を製造することができる。

【００１８】図４～図６は本発明の第２の実施の形態を示す。図４及び図６において図１及び図３と同一符号は同一部品を示す。この装置では、不純ガス排出手段５８が熱遮蔽部材５６の内周面に配設された不純ガス吸引パイプ５８ａと、不純ガス吸引パイプ５８ａに接続された吸引装置（図示せず）とを有する。熱遮蔽部材５６は黒鉛により形成され、下方に向うに従って直径が小さくなる筒状の筒状部５６ａと、この筒状部５６ａの上端から外方に略水平方向に張り出す円板状のフランジ部５６ｂとを有する（図４～図６）。筒状部５６ａ及びフランジ部５６ｂは上記第１の実施の形態の筒状部及びフランジ部のような空洞部を有しないことを除いて、第１の実施の形態の筒状部及びフランジ部と略同一形状に形成される。

【００１９】不純ガス吸引パイプ５８ａは黒鉛によりリング状に形成された単一のパイプであり、筒状部５６ａの内周面に沿って水平に配設される。また不純ガス吸引パイプ５８ａには所定の間隔をあけて複数の不純ガス吸引孔５８ｂが形成される。吸引装置は第１の実施の形態の吸引装置と同じ装置が用いられ、チャンバ１１外に設けられる。不純ガス吸引パイプ５８ａは不純ガス排出パイプ５８ｃを介して吸引装置に接続され、不純ガス排出

パイプ５８ｃは不純ガス吸引パイプ５８ａを保持する役割も果たす。また不純ガス排出パイプ５８ｃには不純ガス流量調整弁２８ｂが設けられる。上記以外は第１の実施の形態と同一に構成される。

【００２０】このように構成されたシリコン単結晶の引上げ装置では、熱遮蔽部材５６の筒状部５６ａ内周面に沿って流下する不純ガス（不純物を含む不活性ガス）が不純ガス吸引孔５８ｂから吸引され、不純ガス吸引パイプ５８ａ及び不純ガス排出パイプ５８ｃを通ってチャンバ１１外に排出されることを除いて、動作は上記第１の実施の形態と略同様であるので、繰返しの説明を省略する。また第１の実施の形態と異なって、この実施の形態の不純ガス排出手段５８は既製の熱遮蔽部材５６に付加して設けることができる。なお、この実施の形態では、単一の不純ガス吸引パイプを熱遮蔽部材の筒状部内周面に沿って配設したが、２本以上の不純ガス吸引パイプを熱遮蔽部材の筒状部内周面に沿って配設してもよい。

【００２１】

【実施例】次に本発明の実施例を比較例とともに詳しく説明する。

＜実施例１＞図１～図３に示すように、チャンバ１１内に空洞部２６ｃを有する黒鉛製の熱遮蔽部材２６を挿入してこの熱遮蔽部材２６の上壁を保温筒１９の上面に設置し、第１流量調整弁２７ｃを調整することによりガス供給パイプ２７ａからチャンバ内１１にアルゴンガスを３０リットル／分の流量で供給した。また第２流量調整弁２７ｄを調整することによりチャンバ１１内のアルゴンガスをガス排出パイプ２７ｂから２５リットル／分の流量で吸引し、不純ガス流量調整弁２８ｂを調整することにより筒状部２６ａ内周面を流下するアルゴンガスを不純ガス吸引孔２６ｅから５リットル／分で吸引した。チャンバ１１内の不活性ガスの圧力はこの不活性ガスの供給口付近で０．０２０ｋｇ／ｃｍ²であった。上記石英るつぼ１３の内径は４００ｍｍであり、この石英るつぼ１３に貯留されたシリコン融液１２の重量は４０ｋｇであった。熱遮蔽部材２６の筒状部２６ａの上端及び下端の内径はそれぞれ３５０ｍｍ及び２００ｍｍであり、筒状部２６ａの高さは３００ｍｍであった。また各不純ガス吸引孔２６ｅの幅及び長さはそれぞれ１０ｍｍ及び５０ｍｍであり、これらの個数は２４個であった。更に筒状部２６ａ下端及びシリコン融液１２表面間の距離は２５ｍｍであった。

【００２２】＜実施例２＞図４～図６に示すように、シリコン単結晶棒２５外周面と石英るつぼ１３内周面との間にシリコン単結晶棒２５の外周面を包囲するように空洞部のない黒鉛製の熱遮蔽部材５６を挿入し、この熱遮蔽部材５６の筒状部５６ａ内周面に沿って単一の不純ガス吸引パイプ５８ａを配設した。第１流量調整弁２７ｃを調整することによりガス供給パイプ２７ａからチャンバ内１１にアルゴンガスを３０リットル／分の流量で供給した。また第２流量調整弁２７ｄを調整することによりチャンバ１１内のアルゴンガスをガス排出パイプ２７ｂから２５リットル／分の流量で吸引し、不純ガス流量調整弁２８ｂを調整することにより筒状部５６ａ内周面を流下するアルゴンガスを不純ガス吸引孔５８ｂから５リットル／分で吸引した。チャンバ１１内の不活性ガスの圧力はこの不活性ガスの供給口付近で０．０２０ｋｇ／ｃｍ²であった。熱遮蔽部材５６の寸法は実施例１の熱遮蔽部材の寸法と略同一であり、不純ガス吸引パイプ５８ａのリング内径及びパイプ５８ａ自体の内径はそれぞれ２００ｍｍ及び１５ｍｍであった。また不純ガス吸引パイプ５８ａには直径５ｍｍの不純ガス吸引孔５８ｂを１２個形成した。更に不純ガス吸引パイプ５８ａは筒状部５６ａの下端から６０ｍｍ上方に配設した。上記以外は実施例１と同一に構成した。

【００２３】＜比較例１＞図７に示すように、シリコン単結晶棒５の外周面と石英るつぼ３の内周面との間にシリコン単結晶棒５を囲むように実施例２と同一形状の熱遮蔽部材６を挿入し、ガス供給パイプ（図示せず）からチャンバ１内にアルゴンガスを３０リットル／分の流量で供給し、チャンバ１内のアルゴンガスをガス排出パイプ（図示せず）から３０リットル／分の流量で吸引した。チャンバ１内の不活性ガスの圧力はこの不活性ガスの供給口付近で０．０２０ｋｇ／ｃｍ²であった。また実施例２の不純ガス吸引パイプは用いなかった。上記以外は実施例２と同一に構成した。

【００２４】＜比較試験と評価＞実施例１、実施例２並びに比較例１の装置にて直径が１５０ｍｍのシリコン単結晶棒を製造した後、これらのシリコン単結晶棒を厚さ２ｍｍにスライスし、結晶の外周付近に相当する部分を選んで切断して板状試料をそれぞれ作成した。これらの試料の表面を混酸でミラーエッチングし、酸素ドナーの消去のため熱処理を行った後、ＤＬＴＳ（Deep level transient spectroscopy）法によって各試験片内部のＦｅ、Ｍｏ、Ｃｕの濃度をそれぞれ測定した。この測定結果を表１に示す。なお、上記濃度の測定位置は結晶外周から約５ｍｍ内側に相当する部分とした。

【００２５】

【表１】

	Ｆｅ濃度 (cm^{-3})	Ｍｏ濃度 (cm^{-3})	Ｃｕ濃度 (cm^{-3})
実施例１	$<10^{10}$	$<10^{10}$	$<10^{10}$
実施例２	$<10^{10}$	$<10^{10}$	$<10^{10}$
比較例１	5.5×10^{11}	1.0×10^{12}	2.5×10^{11}

【００２６】表１から明らかなように、実施例１及び実施例２では金属不純物濃度がＤＬＴＳ法の検出下限以下であり、比較例１と比較して殆ど汚染のない高純度の結晶を得ることができた。

【００２７】

【発明の効果】以上述べたように、本発明によれば、シリコン単結晶棒及び熱遮蔽部材間を流下する不活性ガスのうち熱遮蔽部材の表面に沿って流下する不純物を含む不活性ガスをシリコン単結晶棒に接近する前に不純ガス排出手段が吸引してチャンバ外に排出するように構成したので、シリコン単結晶棒周囲の不活性ガスは不純物を殆ど含まず、上記シリコン単結晶棒が不純物により汚染されることは殆どない。この結果、高純度のシリコン単結晶棒を製造することができる。また熱遮蔽部材内に空洞部を形成し、熱遮蔽部材の内周壁に空洞部に連通して複数の不純ガス吸引孔を形成し、熱遮蔽部材の上部に空洞部に連通して不純ガス排出孔を形成し、更にチャンバ外に設けられた吸引装置を不純ガス排出パイプを介して不純ガス排出孔に接続すれば、熱遮蔽部材内周面に沿って流下する不純物を含む不活性ガスは不純ガス吸引孔から吸引され、空洞部、不純ガス排出孔及び不純ガス排出パイプを通ってチャンバ外に排出されるので、上記と同様の効果が得られる。更に複数の不純ガス吸引孔を有する不純ガス吸引パイプを熱遮蔽部材の内周面に配設し、チャンバ外に設けられた吸引装置を不純ガス吸引パイプに接続すれば、熱遮蔽部材内周面に沿って流下する不純物を含む不活性ガスは不純ガス吸引孔から吸引され、不純ガス吸引パイプを通ってチャンバ外に排出されるので、上記と同様の効果を奏する。

【図面の簡単な説明】

【図１】本発明第１実施形態のシリコン単結晶の引上げ装置を示す図３のＡ部拡大断面図。

【図２】その引上げ装置の不純ガス排出手段を含む熱遮蔽部材の要部破断斜視図。

【図３】その引上げ装置の縦断面図。

【図４】本発明の第２実施形態を示す図６のＢ部拡大断面図。

【図５】その引上げ装置の不純ガス排出手段を含む熱遮蔽部材の要部破断斜視図。

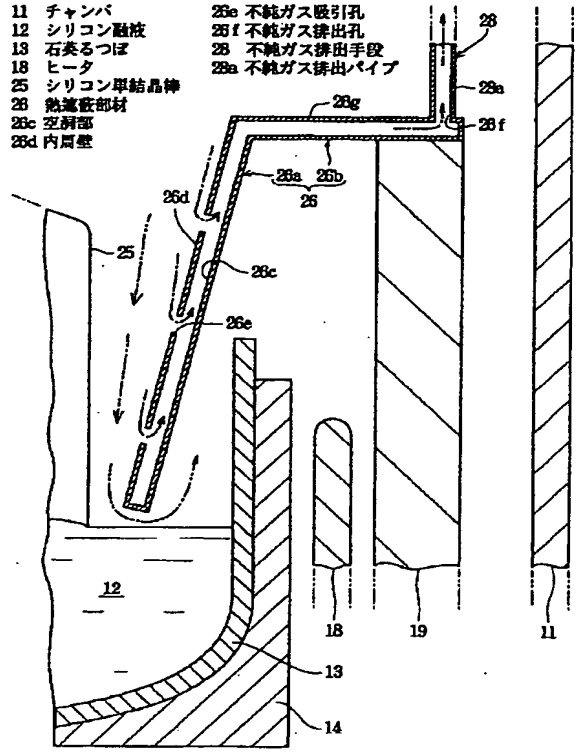
【図６】その引上げ装置の縦断面図。

【図７】従来例を示す図１に対応する断面図。

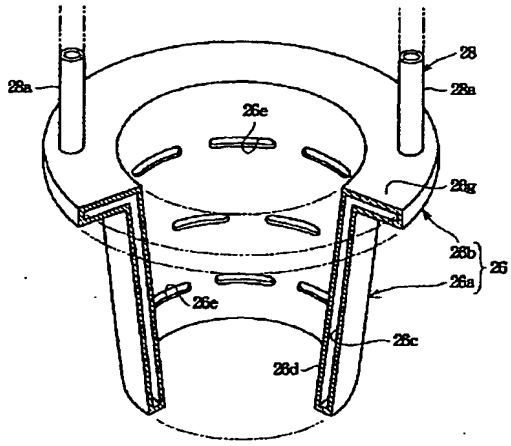
【符号の説明】

１０　シリコン単結晶の引上げ装置
１１　チャンバ
１２　シリコン融液
１３　石英るつぼ
１８　ヒータ
２５　シリコン単結晶棒
２６，５６　熱遮蔽部材
２６ｃ　空洞部
２６ｄ　内周壁
２６ｅ，５８ｂ　不純ガス吸引孔
２６ｆ　不純ガス排出孔
２７　ガス給排手段
２８，５８　不純ガス排出手段
２８ａ　不純ガス排出パイプ
５８ａ　不純ガス吸引パイプ

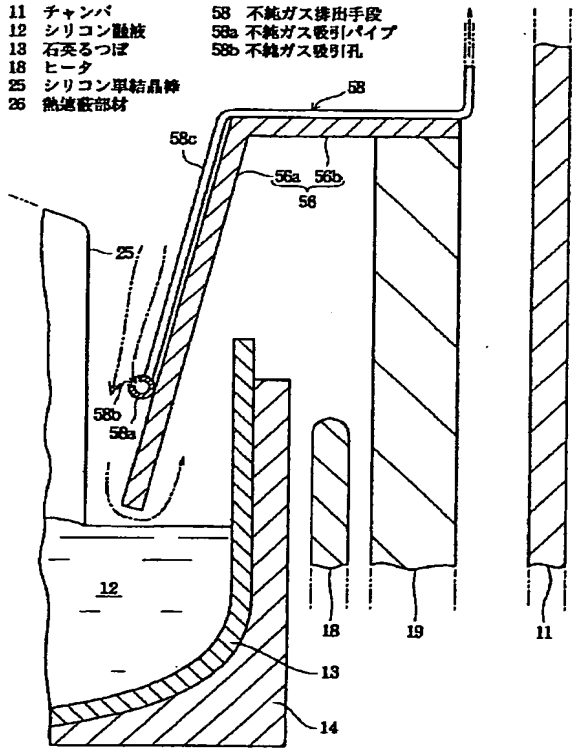
【図1】


11 チャンバ
12 シリコン融液
13 石英るつぼ
18 ヒータ
25 シリコン単結晶棒
26 熱遮蔽部材
26c 空洞部
26d 内周壁
26e 不純ガス吸引孔
26f 不純ガス排出孔
28 不純ガス排出手段
28a 不純ガス排出パイプ
28
28a
26g
26f
28a
26b
26
26d
25
26c
26e
12
18
19
11
13
14

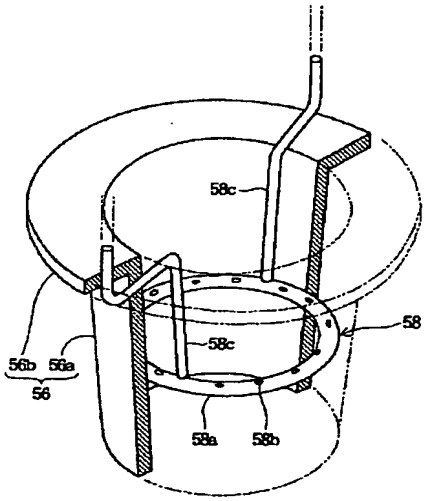
【図2】


28
28a
28a
26e
26g
26b
26
26a
26c
26c
26d

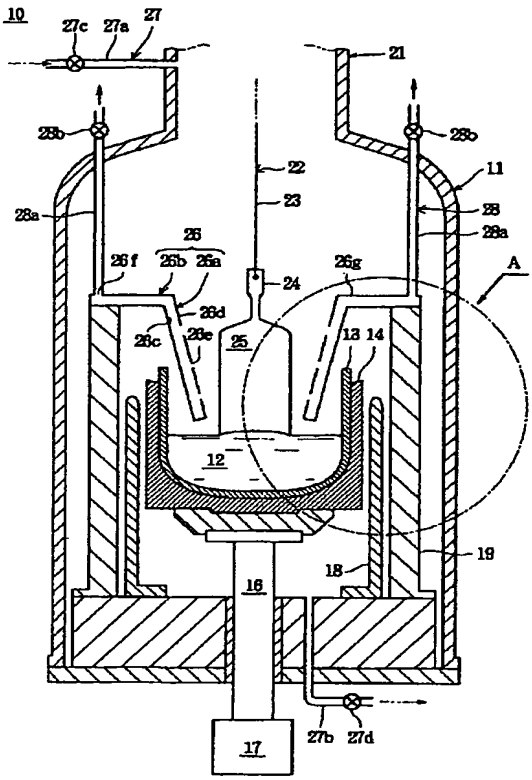
【図4】


11 チャンバ
12 シリコン融液
13 石英るつぼ
18 ヒータ
25 シリコン単結晶棒
26 熱遮蔽部材
58 不純ガス排出手段
58a 不純ガス吸引パイプ
58b 不純ガス吸引孔
58
58c
56a
56b
56
25
58b
58a
12
18
19
11
13
14

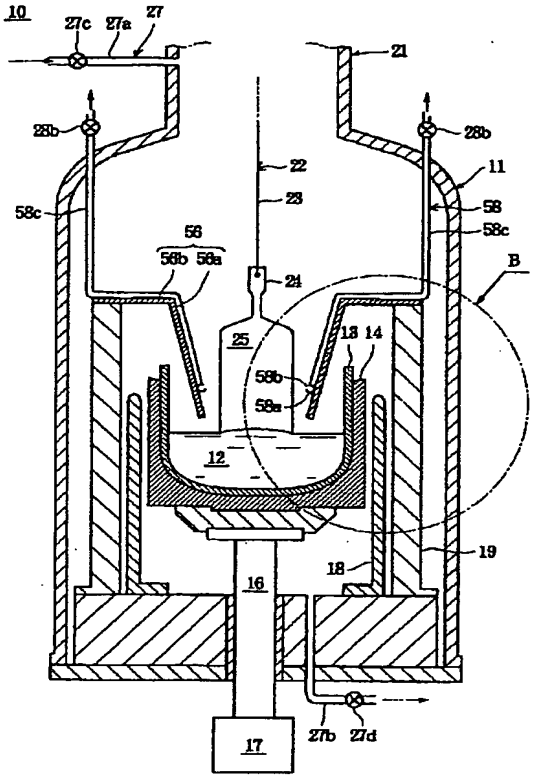
【図5】


58c
58
58c
56b
56a
56
58a
58b

【図３】


10
27c
27a
27
21
28b
28b
22
23
11
28
28a
28a
25
26f
26b
26a
24
26g
A
26d
26c
26e
25
13
14
12
19
18
16
17
27b
27d

【図６】


10
27c
27a
27
21
28b
28b
22
23
11
58c
58
58
58c
56
56b
56a
24
B
25
13
14
58b
58a
12
19
18
16
17
27b
27d

【図７】